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Semiconductor device and method of burning in the same.

Since the power-supply and/or signal-transmission wiring layers (12, 13; 14) connected to the semiconductor chip regions (11) are formed, each individual integrated circuit can be burned in on the semiconductor wafer (10) and, in other words, an integrated circuit can be burned in on a wafer level. The integrated circuit can thus be burned in at the end of a wafer process. An assembled semiconductor device is subjected to a high temperature or a high humidity, for checking the reliability of the assembled device.

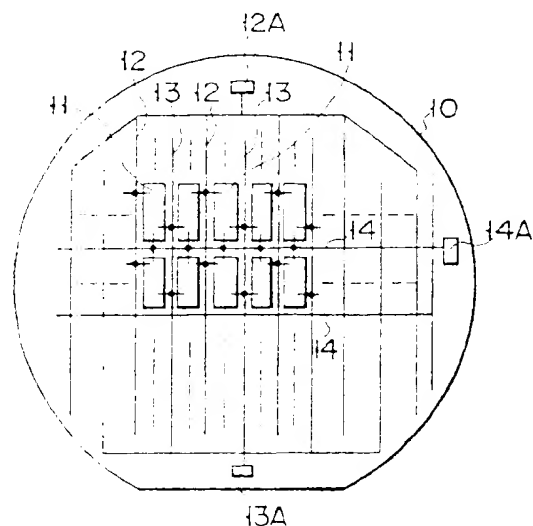


FIG. 1

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## SEMICONDUCTOR DEVICE AND METHOD OF BURNING IN THE SAME

The present invention relates to a semiconductor device comprising a semiconductor wafer having a plurality of IC chip regions and a method of burning in the same.

There are two purposes of burning in a semiconductor integrated circuit. The first purpose is to positively find a latent defect (e.g., a defect in an oxide film) caused in a wafer process so that only a perfect product can be selected in the subsequent screening process. In the first purpose, a semiconductor integrated circuit is burned in by applying a great electrical stress, i.e., by applying a high voltage, under a high ambient temperature. The second purpose is to positively find a latent defect

by process so that only a perfect product can be selected in the subsequent screening process. In the second purpose, a semiconductor integrated circuit is not necessarily burned in by applying an electrical stress and it is subjected to an environmental stress such as a high temperature or a high humidity, for checking the reliability of the assembled device.

Semiconductor integrated circuits have been conventionally burned in with each individual IC chip finished as a semiconductor device and, in other words, with each individual IC chip packaged. For this reason, a burn-in equipment is enlarged and complicated, and an investment for the burn-in equipment is increased and a cost of ensuring a place required for storing the burn-in equipment is heightened, which greatly increases the manufacturing costs of a semiconductor integrated circuit device. Since the burn-in operation is carried out with IC chips packaged, even a semiconductor integrated circuit such as a memory having a redundancy circuit suffers from the problem wherein latent defects cannot be eliminated and the yield of IC chips is difficult to be improved.

The present invention has been made in order to solve the above problem and its object is to provide a semiconductor device and a method of burning in the same wherein an integrated circuit can be burned in at the end of a wafer process.

According to an aspect of the present invention, there is provided a semiconductor device comprising a semiconductor wafer having a plurality of IC chip regions, and a plurality of power-supply and/or signal-transmission wiring layers connected to the IC chip regions and formed on the semiconductor wafer.

According to another aspect of the present invention, there is provided a method of burning in a semiconductor device comprising a plurality of IC chip regions and a semiconductor wafer including

power-supply and/or signal-transmission wiring layers connected to the IC chip regions, wherein a power supply voltage and/or a signal is applied to the wiring layers.

Since the power-supply and/or signal-transmission wiring layers connected to the semiconductor chip regions are formed, each individual integrated circuit can be burned in on the semiconductor wafer and, in other words, an integrated circuit can be burned in on a wafer level. The integrated circuit can thus be burned in at the end of a wafer process. An assembled semiconductor device is subjected to a high temperature or a high humidity for checking the reliability of the assembled device.

equipment can be reduced and an area for installing it can be made small, which decreases the manufacturing costs of a semiconductor integrated circuit device. It is of course necessary to employ a new burn-in equipment capable of applying an electrical or thermal stress to the integrated circuit on the wafer. Such a new burn-in equipment is much simpler and smaller than a conventional burn-in equipment. Furthermore, manufacturing costs of the new burn-in device are low and an area for installing the device is small. If a burn-in operation is performed before dicing for separating the wafer into chips and then a screening test is carried out, a defective integrated circuit can be replaced with an auxiliary normal integrated circuit in a semiconductor integrated circuit device (e.g., memory) including a redundancy circuit and, in other words, a defective integrated circuit can be eliminated and thus the yield of IC chips is improved.

This invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a schematic view showing the configuration of a semiconductor device according to an embodiment of the present invention;

Figs. 2A and 2B are cross-sectional views of a semiconductor device;

Fig. 3 is a view specifically showing part of the configuration of the semiconductor device shown in Fig. 1 and used for explanation of connection between power supply wiring layers and IC chip regions;

Fig. 4 is a schematic view showing the configuration of a semiconductor device according to another embodiment of the present invention;

Fig. 5 is a circuit diagram specifically showing part of an IC chip region of the semiconductor

device shown in Fig. 1 or 4 and used for explanation of connection between an integrated circuit and power supply wiring layers;

Fig. 6 is a circuit diagram showing a number of integrated circuits to which a voltage stress is applied to burn in the semiconductor device of the present invention;

Fig. 7 is a circuit diagram showing a number of integrated circuits to which a voltage stress is applied to burn in the semiconductor device of the present invention; and

Figs. 8A and 8B are cross-sectional views of the semiconductor device shown in Fig. 1.

Embodiments of the present invention will be described in detail when taken in conjunction with the accompanying drawings.

Fig. 1 is a schematic view showing a semiconductor device according to the first embodiment of the present invention. In Fig. 1, semiconductor wafer 10 has a plurality of IC chip (e.g., dynamic RAM chip) regions 11. A plurality of power supply wiring layers 12 and 13 is formed on semiconductor wafer 10 and connected to a power supply for driving circuits in IC chip regions 11. Wiring layers 12 and 13 are formed on dicing line regions between chip regions 11 in the longitudinal direction of Fig. 1.

Wiring layers 12 and 13 are alternately arranged on the dicing line regions of the semiconductor wafer in the longitudinal direction of Fig. 1. Adjacent two wiring layers 12 and 13 are connected to a power supply terminal (not shown) of chip region 11 interposed between the wiring layers (Fig. 3). Signal (e.g., clock signal) transmission wiring layer 14, which is supplied with a signal for controlling the operation of a circuit of chip region 11, is formed on a dicing line region in a direction perpendicular to wiring layers 12 and 13, in other words, in a lateral direction of Fig. 1. Wiring layer 14 is connected to a signal terminal (not shown) of chip region 11 which is adjacent to wiring layer 14.

Wiring layers 12, 13 and 14 are made of, e.g., aluminum and can be formed by the same patterning as that for a wiring layer formed in each of chip regions 11.

A circuit (not shown) for generating a signal for controlling a chip operation during the burn-in process is formed on chip regions or on dicing line regions and is supplied with a power supply voltage from wiring layer 12 or 13. Contact terminals 12A and 13A are formed on the wafer. Contact terminal 12A is connected in common to plural wiring layers 12 and contact terminal 13A is connected in common to plural wiring layers 13. Contact terminals 12A and 13A receive power supply voltages  $V_1$  and  $V_2$  from the outside of the wafer and apply these voltages to wiring layers 12 and 13. Contact terminal 14A is formed on the wafer and connected to plural wiring layers 14. Contact

terminal 14A receives a signal from the outside of wafer and supplies it to wiring layer 14. As illustrated in Fig. 1, contact terminals 12A and 13A are formed at both ends of the wafer. Fig. 8A shows an example of a cross-sectional view of the semiconductor device shown in Fig. 1. In Fig. 8A, the wiring layer 14 is formed on the semiconductor wafer 10, an insulation film is on the structure, and the wiring layers 12 and 13 are formed on the insulation film and separated from each other. Wiring layers 12 and 13 cross wiring layer 14, with the insulation film provided therebetween.

Fig. 8B shows another example of a cross-sectional view of the semiconductor device shown in Fig. 1. In Fig. 8B, wiring layers 12 and 13 are formed on the semiconductor wafer 10 and separated from each other. An insulation film (not shown) is formed on the structure, and the wiring layer 14 is formed on the insulation film. Wiring layers 12 and 13 cross wiring layer 14, with the insulation film provided therebetween.

When an insulation film is interposed between wiring layers 12 and 13, these wiring layers can be arranged in parallel to each other as shown in Fig. 2A, and they can cross each other as shown in Fig. 2B. Wiring layer 14 is formed on another insulation film which is formed on wiring layer 13 (Figs. 2A and 2B). Otherwise, wiring layer 14 can be formed on the lowermost layer of the wafer or on a layer between layers 12 and 13. In this multi-layered structure, a first, second and third wiring layers can be made of polysilicon, silicide and metal, respectively. All the wiring layers can be made of metal. The metal is preferably aluminum; however, other kind of metal can be used.

Each of chip regions 11 formed on wafer 10 shown in Fig. 1 is finally divided into chips after the burn-in process, and the chips are then assembled and finished as integrated circuits. Chip regions (e.g., chip regions for test elements required at the stage of development) to which neither power supply wiring layers nor signal transmission wiring layers are connected, can be formed on wafer 10. When different integrated circuits are formed between chip regions, a common wiring layer is connected to a chip regions for the same integrated circuit.

In burning in integrated circuits 11 on wafer 10, wafer 10 is attached to a socket (not shown), and predetermined power supply voltage  $V_1$  and ground voltage  $V_2$  are externally applied to integrated circuits 11 through contact pads 12A and 13A. If ordinary power supply voltage  $V_{DD}$  is used as  $V_1$  and ground voltage  $V_{SS}$  is used as  $V_2$ , a static burn-in operation can be performed and, in this case, no probe cards are needed. When the need arises, a power supply voltage can be directly applied to the semiconductor wafer.

According to the first embodiment of the present invention, since the power supply wiring layer and the signal transmission wiring layer, which are connected to the chip regions, are formed, each individual integrated circuit can be burned in on the semiconductor wafer and, in other words, the burn-in of each integrated circuit can be performed on a wafer level. The integrated circuit can thus be burned in at the end of the wafer process. If the integrated circuits are assembled into a semiconductor device, it is subjected to a high temperature and a high humidity, for checking the reliability of the assembled device.

Consequently, a burn-in equipment can be simplified and miniaturized, and an investment for the burn-in equipment can be reduced and an area for installing it can be made small, which de-

sary to employ a new burn-in equipment capable of applying an electrical or thermal stress to the integrated circuit on the wafer. Such a new burn-in equipment is much simpler and smaller than a conventional burn-in equipment. Furthermore, manufacturing costs of the new burn-in equipment are low and an area for installing the device is small. If a burn-in operation is performed before dicing for separating the wafer into chips and then a screening test is carried out, a defective integrated circuit can be replaced with an auxiliary normal integrated circuit in a semiconductor integrated circuit device (e.g., memory) including a redundancy circuit and, in other words, a defective integrated circuit can be saved and thus the yield of IC chips is improved.

After the integrated circuit on the wafer is burned in, the wafer is diced and finally separated into a plurality of chips. The power supply and signal transmission wiring layers are thus cut on the dicing line regions. In a multi-layered structure, a short circuit may occur between the wiring layers into which an inter layer insulation film and the wiring layers (not shown) in the chips. In order to avoid the short circuit, it is desirable to separate the power supply and signal transmission wiring layers from the wiring layers in the chips before the dicing. One of specific methods of separating these layers is to cut the connection regions of the power supply and signal transmission wiring layers and the wiring layers in the chips. If these wiring layers are made of aluminum, the connection regions can be cut by irradiating a laser beam or a convergent ion beam. Another method is to use an element for electrically separating these wiring layers. As the simplest method of separating the wiring layers, if the power supply and signal transmission wiring layers are not necessarily required after the respective chips are finished as integrated circuit devices, these wiring layers are removed before

the dicing.

Fig. 4 is a schematic view showing a semiconductor device according to the second embodiment of the present invention. Since the second embodiment is the same as the first embodiment except in that power supply wiring layers 12 and 13 are formed on each of dicing line regions in the longitudinal direction of a wafer in Fig. 4, the same reference numerals as those in Fig. 1 are added to Fig. 4. In Fig. 4, only one of a plurality of IC chip regions is shown for simplification of the drawing.

In the second embodiment, an integrated circuit can be burned in on the wafer and thus the same effect as that of the first embodiment can be obtained.

An example of the burn-in process will be described with reference to Fig. 5. Fig. 5 illustrates

dynamic RAM chip region. Two power supply wiring layers 12 and 13 are connected to the circuit. In Fig. 5, reference numerals 41, 42 and 43 denote contact terminals on the dynamic RAM chip region; C, a cell capacitor; TR, a transfer gate MOS transistor; WL, a word line; BL, a bit line; and SW, switching MOS transistors inserted in series between word lines WL and power supply wiring layer 12. Power supply wiring layer 13 is connected to the gates of transistors SW. PR indicates a precharging MOS transistor inserted in series between bit line BL and bit line precharging power supply line 44. Precharging signal line  $\phi$ PRE is connected to the gate of the precharging MOS transistor.

In the normal operation of the dynamic RAM, word line drive potential WLD which is higher than ordinary power supply voltage  $V_{cc}$ , is applied to a selective word line WL. The highest reliability is therefore required for the transfer gate MOS transistor whose gate is connected to word line WL. It is necessary to drive a plurality of word lines in sequence to burn in transfer gate MOS transistors TR connected to the word lines. The number of word lines selected in one burn-in operation cycle is very small and usually each of the word lines is selected every 1000 cycles only. The efficiency of the burn-in operation is very low. It takes a very long time to burn in only one integrated circuit and the burn-in efficiency becomes much lower.

According to the present invention, the burn-in time can be shortened by the use of a burn-in method wherein a stress is directly applied. The burn-in method of the present invention will be described with reference to the circuit shown in Fig. 5. Bit line precharge power supply line 44 set at ground potential  $V_{ss}$  and precharge signal line  $\phi$ PRE is activated to turn on precharge MOS transistor PR. Power supply voltage  $V_s$  which is sub-

stantially the same as word line drive potential WLD, is applied to power supply wiring layer 12, and power supply voltage  $V_G$  which is higher than power supply voltage  $V_G$  by more than the threshold voltage of transfer gate MOS transistor TR, is applied to power supply wiring layer 13. A direct voltage stress can thus be applied between power supply wiring layer 12 and the bit line BL. If MOS transistor TR is latently defective, it becomes perfectly defective by the direct voltage stress. If no voltage is applied to bit line precharge power supply line 44 or precharge signal line  $\phi$ PRE and power supply voltages  $V_G$  and  $V_G$  are applied to power supply wiring layers 12 and 13, respectively, a direct stress can be applied between power supply wiring layer 12 and the semiconductor substrate. Similarly, if MOS transistor TR is latently defective, it becomes perfectly defective by the direct stress.

When two power supply wiring layers and two signal wiring layers are arranged, if power supply voltage Vcc, ground potential Vss, row address strobe signal RAS, and column address strobe signal CAS are supplied to these wiring layers, the burn-in operation can be carried out in CAS before RAS refresh mode.

In the first and second embodiments, since power supply wiring layers 12 and 13 and signal transmission wiring layer 14 are formed by the same patterning as that of the wiring layers formed in the chip regions, a manufacturing process can be simplified. These wiring layers are made of aluminum in the above embodiments; however, they can be made of polysilicon or silicide.

In the first and second embodiments, the power supply and the signal transmission wiring layers and wiring layers used in the chip regions are formed by patterning the same wiring layer. However, the power supply and signal transmission wiring layers can be formed by patterning different wiring layers, and can be connected to wiring layers used in the chip regions through a contact hole or a bonding wire and, in this case, a wiring scheme can be achieved regardless of an element pattern of each of the chip regions. The power supply wiring layers can have a single-layered structure wherein they are formed on the same insulation film or a multi-layered structure wherein they are separated by an interlayered insulation film. Further, it is possible to form a multi-layered structure consisting of the power supply and signal transmission wiring layers and the wiring layers used in the chip regions. It is also possible to form a wiring layer for exclusively performing a burn-in operation in an operation mode which cannot be executed in a packaged state or performing a burn-in operation so as to apply a stress to a part of the integrated circuit.

Even when the wiring layer for exclusively performing the burn-in operation is formed, a short circuit may occur between the power supply and signal transmission wiring layers and the wiring layers in the chip regions, or between these wiring layers and the semiconductor substrate, when the integrated circuits on the wafer are separated. To prevent the short circuit, it is desirable that the power supply and signal transmission wiring layers are separated from the wiring layers in the chip regions before the dicing. The method of separating these wiring layers has been already described above.

When a voltage is applied to a number of integrated circuits in the burn-in process and then a short circuit occurs between the Vcc and Vss power supplies in a chip, this short circuit affects a voltage which is applied to another integrated circuit for a burn-in operation. To eliminate this influence, it is desirable that a resistor having a proper value is arranged between the power supply and signal transmission wiring layers and the wiring layers formed in the chip regions. The resistance of the resistor is set to be higher, preferably much higher than a sheet resistance of each of the wiring layers.

The resistance of the resistor will be described in detail with reference to Figs. 6 and 7. Fig. 6 illustrates a circuit in which power supply wiring layers 12 and 13 are connected to Vcc and Vss power supplies, respectively, to apply a voltage stress to a number of chips 11<sub>1</sub>, 11<sub>2</sub>, ..., 11<sub>n</sub> in Fig. 6, R represents resistors of wiring layers 12 and 13.

Assuming that there is a short circuit between the Vcc power supply and the Vss power supply in integrated circuit 11<sub>1</sub>, a great number of currents flow into integrated circuit 13<sub>1</sub> and a voltage drops by resistance R of each of power supply wiring layers 12 and 13. Therefore, a voltage of a predetermined level for a burn-in operation is applied to neither integrated circuits 11<sub>1</sub> and 11<sub>2</sub> located farther than integrated circuit 11<sub>3</sub> from power supplies Vcc and Vss nor integrated circuit 11<sub>4</sub> located close to integrated circuit 11<sub>3</sub> but nearer to the power supplies than integrated circuit 11<sub>3</sub>.

To avoid the above, as illustrated in Fig. 7, a resistor r is interposed between each of power supply wiring layers 12 and 13 and wiring layer used in each of the chip regions. Even if there is a short circuit between power supplies Vcc and Vss in integrated circuit 11<sub>1</sub>, the currents flowing into integrated circuit 11<sub>3</sub> are restricted by resistor r. If the resistance of resistor r is much larger than resistance R of the power supply wiring layers, the voltage drop of the power supply wiring layers due to the currents flowing into integrated circuit 11<sub>3</sub> is not so great and can be neglected. A voltage

having a predetermined level for a burn-in operation is thus applied to integrated circuits 11<sub>1</sub> and 11<sub>2</sub> located farther than integrated circuit 11<sub>3</sub> from the power supplies and integrated circuit 11<sub>4</sub> located close to integrated circuit 11<sub>3</sub>.

In the above embodiments, since the power supply and signal transmission wiring layers are formed as wiring layers connected to a plurality of semiconductor chip regions, the integrated circuits can be easily burned in on the wafer level. Even when only one of the wiring layers is formed, the integrated circuits can be burned in on the wafer level.

As described above, according to the semiconductor memory device of the present invention, an integrated circuit can be burned in on a wafer at the end of the wafer process. A burn-in equipment

on one of a single layer and an insulation film interposed therebetween.

7. A semiconductor device according to any one of claims 2 to 6, characterized in that said wiring layers are formed by patterning a wiring layer from which wiring layers used in said chip regions are formed by the patterning.

8. A semiconductor device according to claim 7, characterized in that said wiring layers (12, 13, 14) are formed on dicing line regions on said semiconductor wafer.

9. A semiconductor device according to claim 8, characterized in that said wiring layers are disconnected from said wiring layers used in said chip regions before dicing.

10. A semiconductor device according to any one of claims 2 to 9, characterized in that said wiring

and an area for installing it can be made small, which decreases the manufacturing costs of a finally-finished semiconductor integrated circuit device.

Reference signs in the claims are intended for better understanding and shall not limit the scope.

#### Claims

1. A semiconductor device characterized by comprising a semiconductor wafer (10) having a plurality of IC chip regions (11), and wiring layer means (12, 13, 14) connected to said IC chip regions and formed on said semiconductor wafer.

2. A semiconductor device according to claim 1, characterized in that said wiring layer means (12, 13, 14) comprises a plurality of wiring layers (12, 13, 14) connected to said IC chip regions and formed on said semiconductor wafer.

3. A semiconductor device according to claim 2, characterized in that said wiring layers (12, 13, 14) are power supply lines (12, 13) for driving said IC chip regions and/or signal transmission lines (14) for controlling operations of said IC chip regions.

4. A semiconductor device according to claim 2, characterized in that said semiconductor wafer is connected to said wiring layers, and contact terminals (12A, 13A, 14A) for receiving a power supply voltage and/or a signal from an outside of said semiconductor wafer and applying the power supply voltage and/or the signal to said wiring layers, are formed on said semiconductor wafer.

5. A semiconductor device according to claim 2, characterized in that said plurality of IC chip regions are divided into chips, and each of said chips is finished as an integrated circuit.

6. A semiconductor device according to claim 2, characterized in that said wiring layers are formed

said chip regions are formed by patterning.

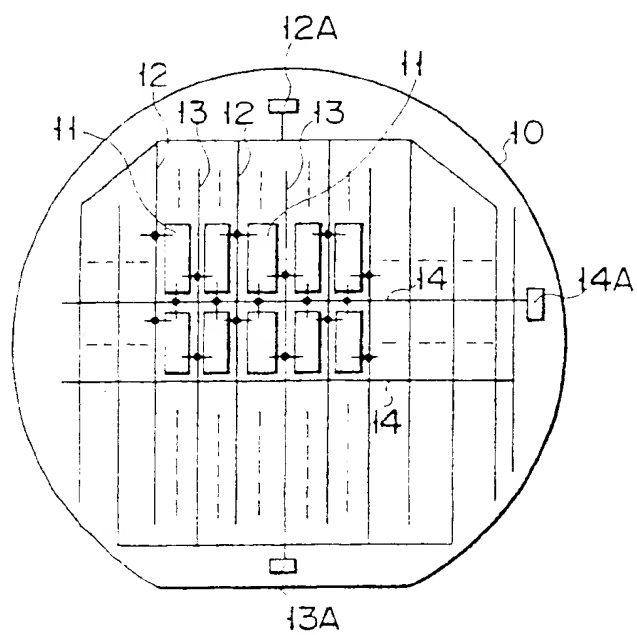
11. A semiconductor device according to claim 10, characterized in that said wiring layers (12, 13, 14) are formed on dicing line regions on said semiconductor wafer.

12. A semiconductor device according to claim 11, characterized in that said wiring layers are removed before dicing.

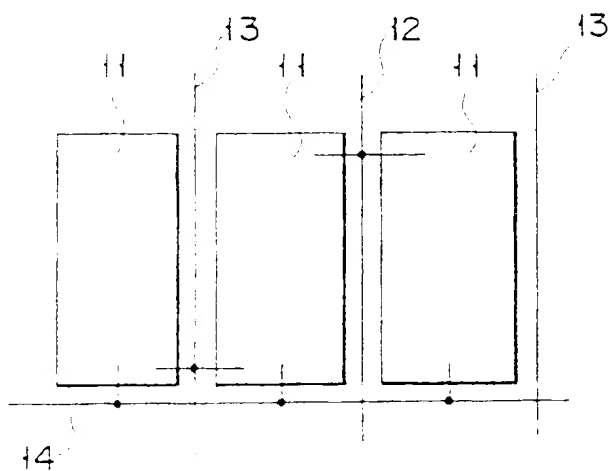
13. A semiconductor device according to any one of claims 2 to 12, characterized in that a resistor element (r) is interposed between said wiring layers and wiring layers used in said chip regions.

14. A semiconductor device according to claim 13, characterized in that said resistor element has a resistance which is higher than a sheet resistance of said wiring layers.

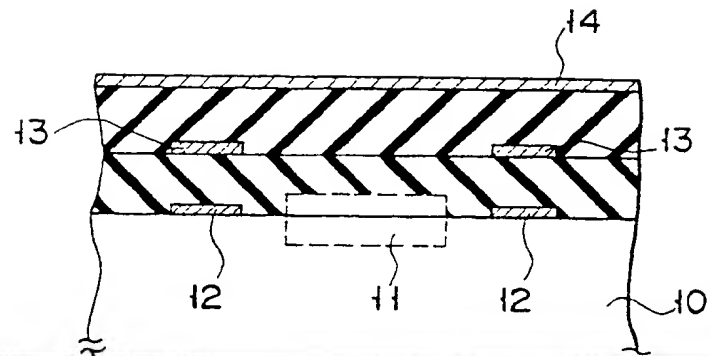
15. A method of burning in a semiconductor device characterized by comprising a plurality of IC chip regions and a semiconductor wafer including a plurality of wiring layers connected to the IC chip regions, wherein a burn-in voltage and/or a burn-in signal is applied to said wiring layers.



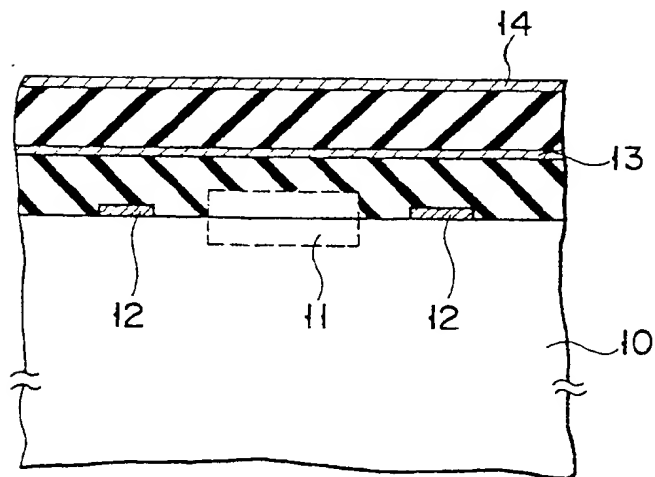
F I G. 1



F I G. 3



F I G. 2A



F I G. 2B



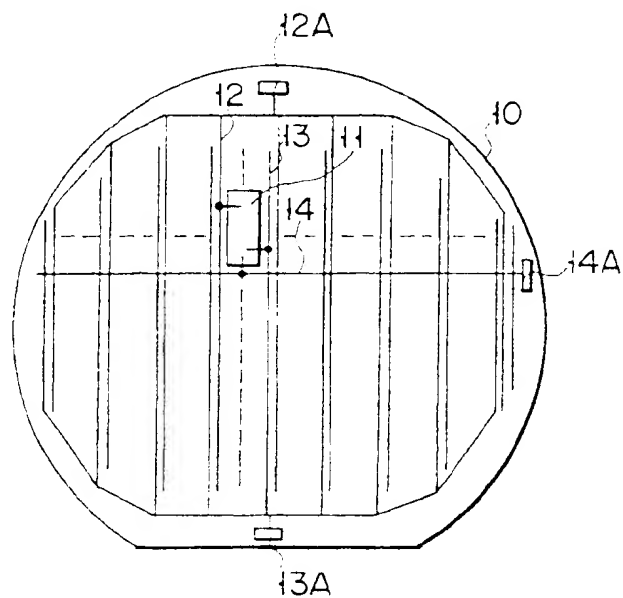


FIG. 4

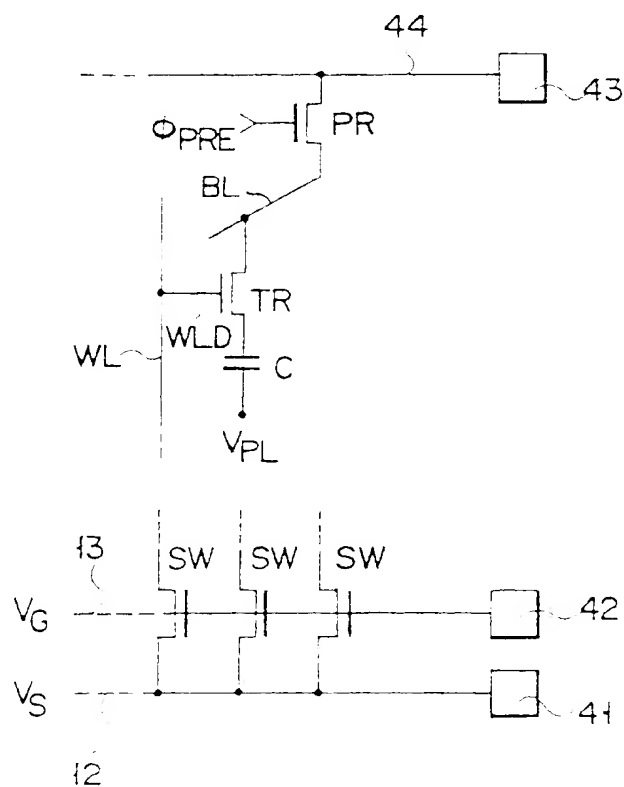


FIG. 5

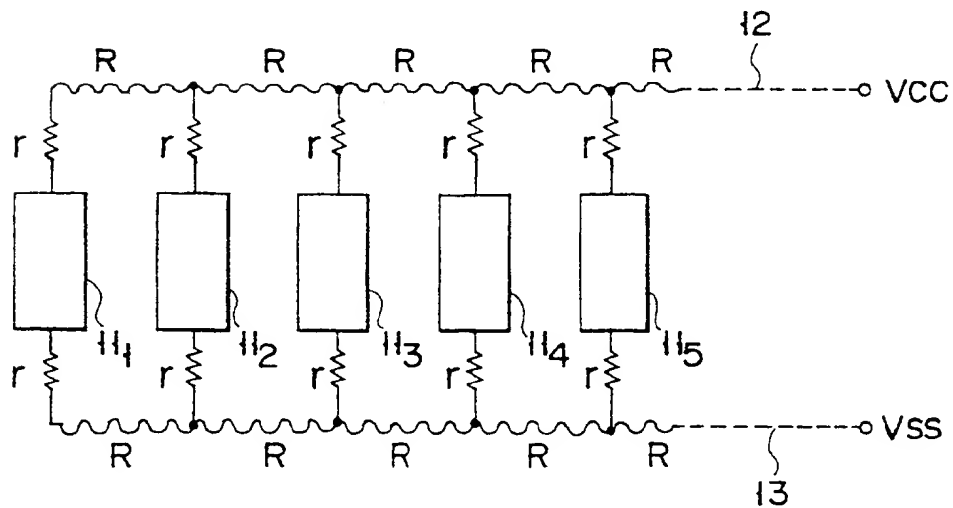
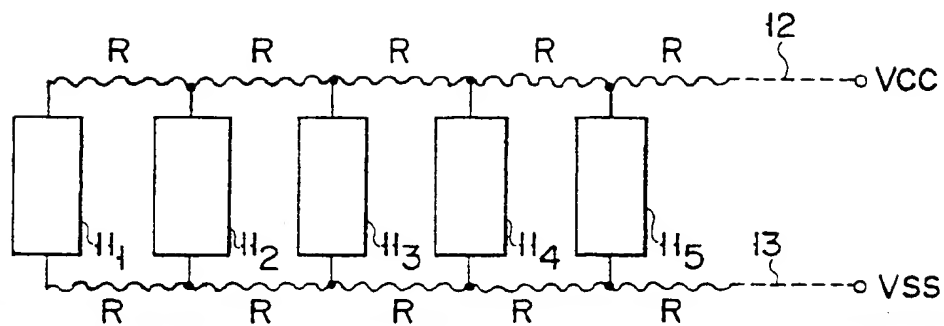


FIG. 7

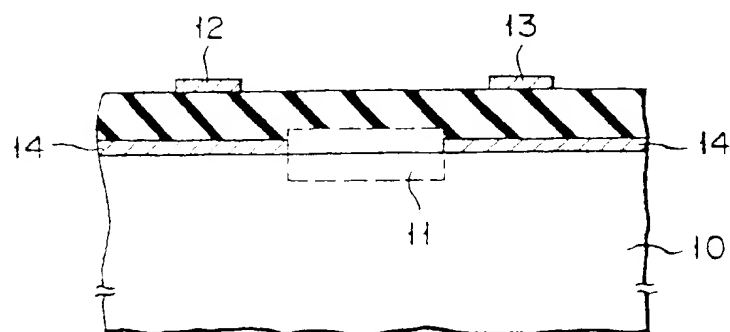


FIG. 8A

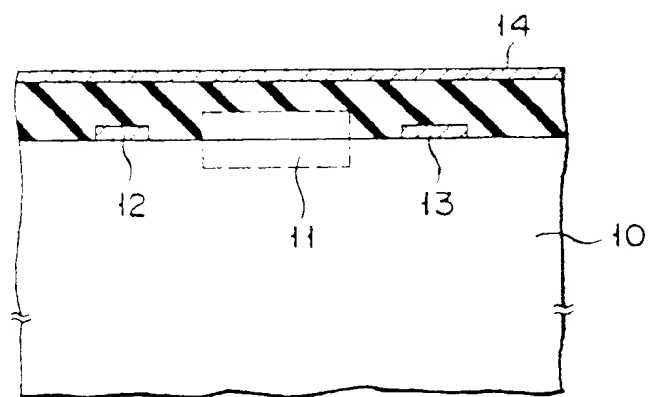


FIG. 8B



European Patent  
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# EUROPEAN SEARCH REPORT

Application Number

EP 90 11 2467

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	IBM TECHNICAL DISCLOSURE BULLETIN, vol. 26, no. 10a, March 1984, NEW YORK US pages 4916 - 4918; G.R. Reinhart and A. Sand: "wafer burn-in" * the whole document *	1, 15	H01L23/52B G06F11/24
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			H01L
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 29 OCTOBER 1990	Examiner PHEASANT N. J.
<b>CATEGORY OF CITED DOCUMENTS</b> X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention F : earlier patent document, not published on, or after the filing date D : document cited in the application I : document cited for other reasons A : member of the same patent family, corresponding document			